The variety of practical work

Practical work in school science has a range of aims. Many authors have proposed ways of classifying these. Hodson (1990, p. 34) suggests that the main reasons given by teachers for using practical work in science teaching are:

- to motivate pupils, by stimulating interest and enjoyment;
- to teach laboratory skills;
- to enhance the learning of scientific knowledge;
- to give insight into scientific method, and develop expertise in using it;
- to develop certain 'scientific attitudes' such as open-mindedness, objectivity and willingness to suspend judgement.

Hofstein and Lunetta (2004, p. 38) offer a similar list of aims but with some differences of emphasis. They suggest that the principal aims of practical work are to enhance students':

- understanding of science concepts;
- interest and motivation;
- scientific practical skills and problem-solving abilities;
- scientific habits of mind;
- understanding of the nature of science.

Hofstein and Lunetta note that the last two points are relatively recent additions to lists of this sort. A later article by Lunetta et al. (2007) includes a similar list (2007, p. 402), but with the addition of 'argumentation from data' to the third aim above. Lazarowitz and Tamir (1994) include the more specific aim of challenging students' misconceptions. In the central section of this chapter, reviewing the research evidence about the effectiveness of practical work, I will use a classification of the aims of practical work based on those discussed above to structure the discussion.

Rather than classifying aims, some researchers have tried to classify types of practical activities. Woolnough and Alsop (1985) suggest that practical tasks undertaken by students can be classified as:

- exercises (to develop practical skills and techniques);
- experiences (to give students a 'feel' for phenomena);
- investigations (to put students in the role of a 'problem-solving scientist').

To these they then add a fourth category – activities intended to support the learning of scientific ideas, concepts and theories – arguing that these are more effective if presented as teacher demonstrations rather than as practical tasks undertaken by students.

More detailed schemes for describing practical activities, in order to highlight similarities and differences, have also been proposed. Lunetta and Tamir (1981) developed a classification scheme to compare practical tasks in two US high school physics courses. Another was developed by the European *Labwork in Science Education* project (Millar et al., 2002) and used to explore the character of science practical work in upper secondary (senior high) school and university courses in six European countries (Tiberghien et al., 2001). An analysis of a sample of 165 laboratory instruction sheets found few activities that required students to test a prediction, or choose between two explanations. In general, the focus was on observable features of the situation studied rather than explanatory ideas. Many chemistry activities taught a standard procedure, and many physics ones focused on processing numerical data. A modified version of this classification scheme was used by Kapenda et al. (2002) to study practical work in lower secondary (junior high) schools in Namibia. They found that teachers' objectives inferred from lesson observation were often wider than those indicated in their written lesson plans or teaching materials. Much of the value of this sort of research lies in the classification scheme itself, which may be a useful tool for other researchers and for teachers wanting to analyse and review their practice more systematically.

Teachers' views of practical work

Several research studies have explored teachers' declared views on practical work. A study by Kerr (1963) asked a sample of secondary (high) school teachers in England to rank in importance the ten aims of practical work, shown in Table 6.1. Kerr included teacher demonstrations within his definition of practical work. Over 700 teachers in 151 schools responded. Kerr concluded that there was 'a significant measure of agreement among teachers as to the educational values arising from practical work' (1963, p. 95) though this was less

Table 6.1 Kerr's aims of practical work (as used by Beatty and Woolnough, 1982a)

1. To encourage accurate observation and description.
2. To promote a logical reasoning method of thought.
3. To develop specific manipulative skills.
4. To practise seeing problems and seeking ways of solving them.
5. To prepare students for practical examinations.
6. To elucidate the theoretical work as an aid to comprehension.
7. To verify facts and principles already taught.
8. For finding facts and arriving at new principles.
9. To arouse and maintain interest.
10. To make phenomena more real.

marked at upper secondary level. A similar approach was taken by Thompson (1975) (with upper secondary school teachers) and by Beatty and Woolnough (1982a, 1982b), but using an extended list of 20 aims. More recently the same 20-item list of aims was used by Swain et al. (1999, 2000) to compare the views of teachers in Egypt, Korea and the UK, and to explore changes over time in the views of UK teachers. They report inter-country differences that might stem from differences in curriculum emphasis or dominant epistemological perspective, but also considerable stability in UK teachers' views. Aims 1, 2, 9 and 10 (Table 6.1) were ranked highly in all studies of UK teachers.

Some questions might, however, be asked about the methods and instruments used in these studies. It is difficult to state aims of practical work clearly and concisely, and specific choices of words may significantly affect responses. Conclusions drawn from the responses may lack validity – a respondent's interpretation of the statements of aims may differ from that intended by the researchers. The repeatability of a person's ranking of 10 or 20 statements, particularly in the middle of the rank order, is also questionable. Perhaps most significantly, Kerr (1963, pp. 43–6) and Thompson (1975, p. 36) report discrepancies between teachers' rankings and their actual practice. Beatty and Woolnough (1982a, p. 30) similarly acknowledge that their data may not reflect what is taking place in classrooms and laboratories. Wilkinson and Ward (1997) also report marked differences between Australian teachers' stated aims for practical work and the aims perceived by their students. Teachers' ranking of aims may tell us more about the rhetoric of practical work, at the time the study was carried out, than about the practice.

A rather different research approach was used by Donnelly (1998) in a study of teachers' views of teaching their subject. Drawing on data from 40 interviews with science teachers in five schools in England, Donnelly suggests that science teachers typically categorize lessons, or parts of lessons, as 'practical' or 'theory', and that the overwhelming majority see practical work as a constitutive element of 'being a science teacher'. That is, they see it as something which is simply part of what you do as a science teacher, rather than a strategy consciously chosen from a range of options to achieve a specific learning outcome. The fact that many lessons take place in laboratories is likely to be a factor in sustaining this perception. Donnelly reports that only one teacher in his sample expressed qualified scepticism about the value of practical work. He emphasizes that his account is intended to be descriptive, not judgmental. Donnelly's interpretation is in line with the observation of Duschl and Gitomer (1997) that science teachers tend to see their practice in terms of 'tasks and activities rather than conceptual structures and scientific reasoning' (p. 65). Teaching is then a matter of staging a sequence of activities, rather than of producing intended cognitive or behavioural changes. If this is so, it has significant implications for efforts to improve the effectiveness of practical work – suggesting that a necessary first step is to help teachers to see each practical activity as a means to an end, and not as an end in itself.